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CAN BALANCE SKILLS PREDICT OLYMPIC WRESTLING PERFORMANCE?

¿PUEDEN LOS PARÁMETROS ESTABILOMÉTRICOS PREDECIR EL RENDIMIENTO EN LUCHA OLÍMPICA?

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ABSTRACT

The purpose of this study was to analyze the stabilometric parameters of elite and sub-elite wrestlers under rest and fatiguing conditions similar to those which occur during an Olympic wrestling combat. To do that we used the Wii® balance board as a new technology that has been cross-validated to assess standing balance. Sixty two male wrestlers were assigned into 2 groups according to their competitive level: Elite n=28 and Sub-elite n=34. All wrestlers underwent a standardized stabilometric assessment, consisting of the measure of the main postural control variables in double leg and single leg (dominant and non-dominant) standing, all of them on stable and unstable surface, before and immediately after a Wingate anaerobic test (WAnT). These stabilometric variables were: i) the confidence ellipse surface (CES) containing 90% of the sampled positions of the center of pressure (CoP); ii) mean velocity as average modulus of velocity of CoP path; and iii) mean frequency of sway over medial-lateral and anterior-posterior direction from amplitude spectrum. The anaerobic fatigue protocol produced significant ($p<0.05$) balance performance impairment for all wrestlers, except in the CES with double leg stance on stable and unstable surface. Under rest and fatigue conditions, the national level wrestlers do not differ from their international counterparts in any of the stabilometric parameters assessed. Independently of the competitive level, a short but strenuous bout of exercise produces rapid and significant balance postural declines in the static stance of wrestlers, mainly with only one leg support.

Keywords: combat sports; postural balance; body stability; Wii balance board; Wingate; martial arts.

RESUMEN

El propósito de este estudio fue analizar los parámetros estabilométricos de luchadores de élite y sub-élite en reposo y bajo condiciones de fatiga similares a los que ocurren durante un combate de lucha olímpica. Para ello se utilizó la plataforma de equilibrio Wii®, recientemente validada para evaluar los patrones estabilométricos en bipedestación. Sesenta y dos luchadores varones fueron asignados en 2 grupos en función de su nivel competitivo: Élite n = 28 y Sub-élite n = 34. Todos los luchadores se sometieron a una evaluación estabilométrica estandarizada de las principales variables de control postural con apoyo bipodal y monopadal (dominante y no dominante), en superficie estable e inestable, antes e inmediatamente después de un test all-out de 30 s Wingate (WAnT). Las variables estabilométricas estudiadas fueron: i) la superficie de la elipse de confianza (CES) que contiene el 90 % de las posiciones del centro de presión (CoP), ii) la velocidad como el módulo promedio de velocidad de la trayectoria del CoP, y iii) frecuencia media de oscilación medio-lateral y antero-posterior de la dirección del espectro de amplitud. El protocolo de fatiga WAnT produjo descensos significativos en rendimiento de equilibrio para todos los luchadores, excepto en el CES con apoyo monopodal y bipodal tanto en superficie estable como inestable. Bajo condiciones de reposo y de fatiga, los luchadores de nivel nacional no se diferencian de sus homólogos internacionales en ninguno de los parámetros estabilométricos evaluados. Independientemente del nivel competitivo, un esfuerzo físico corto pero extenuante produce descensos rápidos y significativos en el equilibrio postural de los luchadores, en especial con una sola pierna de apoyo.

Palabras clave: Deportes de combate; equilibrio postural; estabilidad corporal; plataforma de equilibrio Wii; Wingate; artes marciales.

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INTRODUCTION

The role of balance in performance and health has been a matter of interest among conditioning specialists and researchers for many years. However, there are few reports related to the influence of balance on sport performance and competitive level. Postural stability is basic, not only in daily-life situations, but also in almost all sports (Hrysomallis, McLaughlin & Goodman, 2006), especially in those combat sports which aim to maintain balance over the adversary, and therefore the role of postural stability is essential (Perrot, C., Mur, J.M., Mainard, D., Barrault, D. & Perrin, P.P., 2000; Perrin, P., Deviterne, D., Hugel, F. & Perrot, C., 2002; Leong, H.T., Fu, S.N., Ng, G.Y. & Tsang, W.W., 2011).

In Olympic wrestling, competitors have to efficiently control their static and dynamic posture, because the techniques of this sport are mainly based on constant displacements, pushes and pulls, aiming to disturb the balance of the opponent in order to make him fall to the mat (Perrot, C., Moes, R., Deviterne, D. & Perrin, P., 1998). Then, during combats, each wrestler learns to use unstable dynamic situations to turn them to his advantage, using the stimulation of muscular, articular and cutaneous mechanoreceptors to adapt to the constant modifications of posture, support, ground and partner contact (Perrot et al., 1998; Perrin et al., 2002). Muscle fatigue, especially following anaerobic strenuous protocols (Fox, Z.G., Mihalik, J.P., Blackburn, J.T., Battaglini, C.L. & Guskiewicz, K.M., 2008) has been shown to negatively influence static postural stability as well as elicit changes in motor unit behavior and central drive characteristics (Ageberg, E., Roberts, D., Holmström, E. & Fridén, T., 2004; Wilkins, J.C., Valovich, McLeod, T.C., Perrin, D.H. & Gansneder, B.M., 2004; Strang, A.J. & Berg, W.P., 2007; Bizid, R., Jully, J.L., González, G., Francois, Y., Dupui, P. & Paillard, T., 2009a; Bizid, R., Margnes, E. & Francois, Y., 2009b; Lin, et al., 2009; Brito et al., 2011). In this sense, several researchers have described the great amount of anaerobic energy expenditure that occurs throughout the 2-3 periods of 2 min that an Olympic wrestling match is composed of (García-Pallarés, J., Lopez-Gullón, J.M., Muriel, X., Díaz, A. & Izquierdo, M., 2011; Barbas, I., Fatouros, I.G., Douroudos, I.I., Chatzinikolaou, A., Michailidis, Y. & Draganidis, D., 2011; López-Gullón, J.M., García-Pallarés, J. & Berenguei Gil, R., 2011a; López-Gullón, J.M., Muriel, X., Torres-Bonete, M.D., 2011b; Pallarés, J.G., López-Gullón, J.M., Torres-Bonete, M.D., Izquierdo, M., 2012; López-Gullón, J.M., Torres-Bonete, M.D. & Berenguei, R., 2012). This anaerobic contribution has been estimated through the metabolic acidosis detected immediately after the end of a wrestling bout (i.e., lactic acid concentrations ranged between 12.1 - 20.0 mmol•L-1) (Barbas et al., 2011, López-Gullón et al., 2012; Kraemer, W.J., Fry, A.C. & Rubin, M.R., 2001; Karnincic, H., Tocilj, Z., Uljevic, O. & Erceg, M., 2009), as well as the great fatigue index detected following a Wingate test performed by highly-trained male and female wrestlers (García-Pallarés et al., 2011, 2012; Hübner-Wozniak, E., Kosmol, A., Lutoslawska, G. & Bem, E.Z., 2004; Melnikov, A.A., Savin, A.A., Emelyanova, L.V. & Vikulov, A.D., 2012). These data highlight the importance of taking into account the physiological and neuromuscular fatigue produced during an official wrestling bout as a balance control disturbance method for a specific training program and test design.

Recent studies have reported that a reduced number of anthropometric, physiological, neuromuscular and psychological factors can differentiate between elite and amateur or sub-elite wrestlers (García-Pallarés et al., 2011, 2012; López-Gullón et al., 2011 y 2012) and even more importantly, these variables could predict up to 89.1% probability of competing at an elite wrestling level (García-Pallarés et al., 2011). Thus, some previous studies found, always under rest conditions, higher stabilometric and balance skills for successful combat sportsmen compared to unsuccessful ones (Paillard, T., Costes-Salon, C., Lafont, C. & Dupui, P., 2012), or simply higher stance balance performance for these combat sportsmen compared to other sport participants or sedentary healthy adults (Perrin 2002; Melnikov et al., 2012; Rynkiewicz, T., Żurek, P. & Rynkiewicz, M., 2010; Leong et al., 2011).

Laboratory-based assessment using measures of center of pressure (CoP) recorded from a force platform have identified important outcome measures which are related to the stabilometric parameters and balance skills of athletes (Perrin et al., 2002; Brito et al., 2011; Yoo, K.S., Kim, H.K. & Park, J.H., 2012) and non-athletes (Hazime et al., 2012; Izquierdo, M., Aguado, X., Gonzalez, R., López, J.L. & Häkkinen, K., 1999). However force platforms are often expensive, difficult to setup and cumbersome to

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transport and therefore this form of balance assessment is often not feasible in several sportive contexts. The Wii® balance board has recently emerged as a new technology that could potentially be used to assess standing balance. The balance board possesses similar characteristics to a laboratory force platform, in that it contains sensors that assess force distribution and the resultant movements of the center of pressure. The key benefits of the balance board over a force platform is that it is portable, inexpensive and can be available in several sport training centers and therefore allow coaches and sport scientists to implement longitudinal studies of a large number of athletes with the same device. Taking a standard force platform as a Gold Standard, the concurrent validity (CCI ranged between 0.77 and 0.98) and reliability (established through a Bland-Altman plot) of this device have recently been established in healthy adults (Clark et al., 2010) and subjects with impaired postural stability (Holmes et al., 2012).

Therefore, the aim of this study is to analyze the stabilometric parameters of elite and sub-elite wrestlers under rest and fatiguing conditions similar to those which occur during an Olympic wrestling combat. If differences exist, this will indicate the importance of these balance skills in wrestling success. We hypothesized that, at least under fatigue conditions, several stabilometric parameters may differentiate Elite and Sub-elite wrestlers.

METHODS

Subjects

Sixty two male wrestlers, 27 Greco-Roman, and 35 Freestyle competitors volunteered to take part in this study. Participants were assigned into 2 groups according to their competitive level: Elite (n = 28) and Sub-elite (n = 34). To be placed in the elite group wrestlers: i) had at least three international participations representing their respective countries in FILA tournaments (i.e., European and/or World Championships) and, ii) had at least 8 years of regular training experience. Furthermore, 18 of them had won at least one medal during an international tournament. Sub-elite wrestlers had been finalists at their respective national championships in the last season, although they had not taken part in any international competition. The physical characteristics and training status of the subjects are presented in Table 1. The subjects were informed in detail about the experimental procedures and the possible risks and benefits of the project. The study complied with the Declaration of Helsinki, was approved by the Bioethics Commission of the University of Murcia, and written informed consent was obtained from each athlete or from their parents prior to participation.

Experimental Design

This study was carried out during an international training camp placed in the final week of a pre-competitive mesocycle. None of the participants reported any physical limitations prior to beginning the experiment, nor any lower limb musculoskeletal injuries in the previous two years that could affect testing. Also, none of these 62 wrestlers were involved in a weight cutting approach or under restricted water or food intakes. All the subjects followed the same dietary plans during the experiments. No strenuous exercise was undertaken 48 h before reporting to the laboratory for testing. All participants underwent two familiarization sessions before the start of the experiment to avoid the bias of progressive learning on test reliability.

Table 1. Subjects' characteristics of Elite and Sub-elite wrestlers.

	Elite (n = 28)	Sub-elite (n = 34)	p
Age (years)	19.1 ± 3.2	18.8 ± 2.4	0.798
Body mass (kg)	70.6 ± 12.7	72.4 ± 18.4	0.670
Height (cm)	170.8 ± 6.0	170.9 ± 5.1	0.803
VO_{2max} (ml·kg^{-1}·min^{-1})	54.0 ± 8.2	47.8 ± 3.6	0.100
Body fat (%)	11.4 ± 4.3	13.2 ± 5.0	0.067
1RM Bench Press/BM	1.1 ± 0.2	0.9 ± 0.2	0.000
1RM Full Squat /BM	1.4 ± 0.2	1.1 ± 0.3	0.001
Training experience (y)	8.2 ± 3.6	6.5 ± 3.8	0.138

The stabilometric assessment consisted of the measure of the main postural control variables in double leg and single leg (dominant and non-dominant) standing, all of them on stable and unstable surface, before (rest - PRE) and immediately after (fatigue-POST) a Wingate anaerobic test

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(WAnT), always with their eyes open. This experimental design aimed to evaluate the differences that the competitive level (Elite vs. Sub-elite) may produce in the postural control tasks at rest (i.e., physiological and neuromuscular conditions similar to those which occur during the first seconds of an official wrestling combat), and after a strenuous anaerobic exercise test, (i.e., similar conditions to the extreme fatigue that occur during the second half of a wrestling combat period) (López-Gullón et al., 2011).

Experimental Protocol

The day before and during the three days that the experiment lasted, the subjects stayed in the sports research center where they slept and ate all their meals. They consumed a diet of 2,800–3,000 kcal•day-1, composed of 55% energy intake from carbohydrates, 25% from fat and 20% from protein, evenly distributed across three meals each day (breakfast at 8:30 a.m., lunch at 13:30 p.m. and dinner at 20:00 p. m.). The day before the onset of the experiment, height was measured to the nearest 0.5 cm during a maximal inhalation using a wall-mounted stadiometer (Seca 202, Seca Ltd., Hamburg, Germany). In every trial, upon arrival to the testing facility, the subjects' body weights were determined and body water estimated in a fasted state using an eight-contact electrode body composition bio-impedance analyzer (Tanita BC-418, Tanita Corp., Tokyo, Japan).

After a standardized warm-up that consisted of 5 min of pedaling a stationary bicycle at low intensity (50-60% FCmax) and 5 min of static stretches and joint mobilization exercises, the subjects entered the laboratory to start the stabilometric assessments. Under rest conditions (PRE), each subject was assessed for balance in 1º) double leg stance on stable surface, single leg stance over 2º) dominant and 3º) non-dominant limbs, and also over an unstable surface (on a polyvinyl chloride foam) for 4º) double leg , single leg over 5º) dominant and 6º) non-dominant limbs. Then, participants performed a 30 s Wingate anaerobic test in a cycle-ergometer individually configured according to the individual characteristics. Immediately after the end of this test (i.e., 90 s), participants´ stabilometric parameters were again assessed under fatigue conditions (POST) on the stable surface for 7º) double leg , single leg over 8º) dominant and 9º) non-dominant limbs, as well as under unstable surface for 10º) double leg , single leg over 11º) dominant and 12º) non-dominant limbs.

Wingate test

All tests were performed on an adjustable cycle-ergometer (Ergomedic 874E, Monark, Varberg, Sweden). Each wrestler completed a habituation warm-up to familiarize themselves with the laboratory environment and testing procedures. The seat was adjusted to a predetermined height to allow for complete knee extension with the ankle flexed at 90º. The test was 30 s in duration and participants were instructed to pedal as powerfully as possible on each revolution throughout the trial and not to adopt any pacing strategy. Power and pedal rate were recorded using 1s data averages. The WAnT was conducted against a fixed resistance of 0.075 kg per kg of body mass. The test started from a complete stop with the crank of the dominant leg at 45° from the vertical. Peak Power (Wpeak) was defined as the greatest power value recorded during the test and minimum power (Wmin) was defined as the smallest power value attained in the last 2-3 seconds. The average power (Wmean) of the 30 s was also established. Fatigue index was calculated as: FI = Wpeak/Wmin. Immediately after the conclusion of the WAnT, participants pedaled during 60 s at 50 W and then proceeded to undertake the fatigue stabilometric assessment (POST). Recent studies have found that a single 30 s Wingate test is a reasonable indicator of the anaerobic metabolism involved in a wrestling bout (López-Gullón et al., 2011).

Stabilometric assesment

For both stabilometric assessments (i.e., PRE and POST) the subjects were barefooted and their eyes remained open and focused on a point 65 cm ahead and 1.8 m high. Participants were instructed to keep their hands placed on their hips and to remain as still as possible for the duration of the trial. For the single leg test, the knee of the contra-lateral limb was flexed and held at about 90º and not permitted to contact the support limb. For the unstable surface tests, participants stepped on to a polyvinyl chloride foam (30 kg•m-3 density and 15 cm thick) positioned on top of the balance board. The start of data collection was manually triggered when the subjects indicated that they were ready. Movements of the center of pressure (CoP) in the frontal or medial-lateral plane and sagittal or anterior-posterior plane were recorded for 30 s in the two leg stance and 10 s for the single leg stance (Clark et al., 2010).

Force Platform and Data Analyses

We used the Wii Balance Board (Nintendo, Kyoto, Japan) as a measuring device and a custom-written digital signal processing software to enable communication. According to recent studies, the Wii Balance Board was shown to exhibit high concurrent validity for CoP assessment with a laboratory-grade force platform (ICC = 0.77–0.98) (Holmes et al., 2012; Clark et al., 2010). A Wii Balance Board has four strain gauges load cells. We obtained pre-calibrated force values of every load cell with sample rate of 40 hz, and used these values to calculate xy-coordinates of a standard Cartesian coordinate system of CoP. With the CoP position along the timeline we were able to compute kinematics and various dispersion measures of CoP displacement.
A custom-written digital signal processing software (Visual Basic.NET, Measurement Studio library National Instruments, Austin, TX, U.S.A, see figure 1) was used to calculate the following variables: i) the confidence ellipse surface containing 90% of the sampled positions of the CoP in cm2 (CES) (Doyle et al., 2007; Gagey et al., 2001a; Schubert, P., Kirchner, M., Schmidtbleicher, D. & Haas, C.T., 2012;); ii) mean velocity as average modulus of velocity of CoP path in cm•s-1 (MV) (Doyle et al., 2007; Schubert et al., 2012); iii) mean frequency of sway over medial-lateral direction from amplitude spectrum in Hz (MFX) iv) mean frequency of Sway over anterior-posterior direction from amplitude spectrum in Hz (MFY) (Gagey et al., 2001b; Schubert et al., 2012; Panjan et al., 2010;). A single value for each of the outcome measures was obtained for each task.

Statistical Analysis

All analyses were performed using the Statistical Package for the Social Sciences software (SPSS Version 19.0). Descriptive values are shown through a series of whisker and box-plot graphs. Effects sizes and percentage of change between PRE and POST conditions were also reported. The Shapiro–Wilk test indicated that data were non- normally distributed. So a Willcoxon rank test was employed to determine the impact of fatigue on each group. To determine differences in the stabilometric parameters between elite and amateur groups after fatigue protocol, a Kruskal-Wallis ANOVA was employed.

Table 2. Changes in the stabilometric parameters studied due to fatigue in the total sample.

	CES (cm^2)		**MV** ($cm \cdot s^{-1}$)		**MFX** (Hz)		**MFY** (Hz)	
	PRE/ POST (%)	Effect Size	PRE/ POST (%)	Effect Size	PRE/ POST (%)	Effect Size	PRE/ POST (%)	Effect Size
2 Legs Stable	-0.16	-0.22	-2.66	-3.37*	-0.70	-3.04*	-0.12	-0.56*
2 Legs Unstable	-0.11	-0.19	-2.62	-3.46*	-0.83	-3.06*	-0.46	2.65*
1 Leg Stable Dominant	0.16	0.33*	-0.48	-1.39*	-0.06	-0.83*	-0.62	-1.70*
1 Leg Unstable Dominant	0.27	0.59*	-0.68	-2.05*	-0.03	-0.50*	-0.83	-2.45*
1 Leg Stable Non-Dominant	0.24	0.78*	-0.42	-1.42*	-0.11	-1.90*	-0.24	0.65*
1 Leg Unstable Non-Dominant	0.21	0.47*	-0.48	-1.40*	-0.13	-2.42*	-0.34	-0.83*

CES: Confidence ellipse surface containing 90% of the sampled positions of the center of pressure; MV: Mean velocity as average modulus of velocity of the center of pressure; MFX: Mean frequency of sway over medial-lateral direction from amplitude spectrum; MFY: Mean frequency of sway over anterior-posterior direction from amplitude spectrum. Willcoxon signed-rank test (* $p < 0.01$).

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RESULTS

The impact of fatigue on balance

As presented in Table 2, a short but intense and extraneous exercise stimulus of only 30 s (Wingate peak power values 925 ± 157 W and 827 ± 233 W for Elite and Sub-elite wrestlers, respectively) produced a significant decrease ($p < 0.05$) in the ability to maintain body balance. The statistical analysis revealed that only CES in double leg standing is not altered by the 30 s fatigue stimulus ($p = 0.335$ and $p = 0.182$ for stable and unstable test, respectively), and all the other variables showed changes from 266 to 27 % (effect size ranged between 0.37 and 3.46), with these differences generally being greater in unstable situations.

Elite – Sub-elite differences

Prior to fatigue protocol, Elite wrestlers do not show better balance patterns than the Sub-elite group, and none of these stabilometric factors studied were differently altered according to competitive level (Elite vs. Sub-elite) immediately after the conclusion of the Wingate test. These absences of differences before and after the fatigue protocol between Elite and Sub-elite groups were established through a Kruskall-Wallis ANOVA. Although Elite subjects tended to perform higher peak power values (925 ± 157 W vs. 827 ± 233 W; $p = 0.08$) and similar fatigue index during the 30 s Wingate test (1.6 ± 0.3 vs. 1.6 ± 0.2) compared to the Sub-elite counterparts, there were no statistically significant differences between competitive levels in any of the stabilometric variables studied.

So it seems that the absence of differences is not related to muscular performance, and the variation in the confidence ellipse surface containing 90% of the sampled positions of the CoP (CES 90%, figure 2A), mean velocity as the average modulus of velocity of CoP path (MV, figure 2B), frontal or medial-lateral plane (MFX, figure 2C) and sagittal or anterior-posterior plane (MFY, figure 2D) is the same for both groups of wrestlers.

DISCUSSION

The purpose of this study was to analyze the stabilometric parameters and body balance of Elite and Sub-elite wrestlers under rest and fatiguing conditions similar to those which occur during an Olympic wrestling combat. Our data supports that this specific anaerobic exercise protocol produces a significant performance decline in all the stabilometric parameters associated with the stance balance. Furthermore, our results suggest that at rest and under anaerobic fatigue conditions, the national level wrestlers do not differ from their international counterparts in any of the stance stabilometric parameters assessed. We consider that these two findings have practical applications to individualize the physical fitness training and testing of wrestlers, and to choose the adequate combat techniques and tactics required to beat the opponent.

One of the major findings in the present study was that all the stabilometric parameters assessed (i.e., CES, MV, MFX and MFY), over stable and unstable surface, mainly with only one leg support, suffered significant performance declines immediately after a short but strenuous bout of anaerobic exercise. The impact of a standardized anaerobic protocol on the

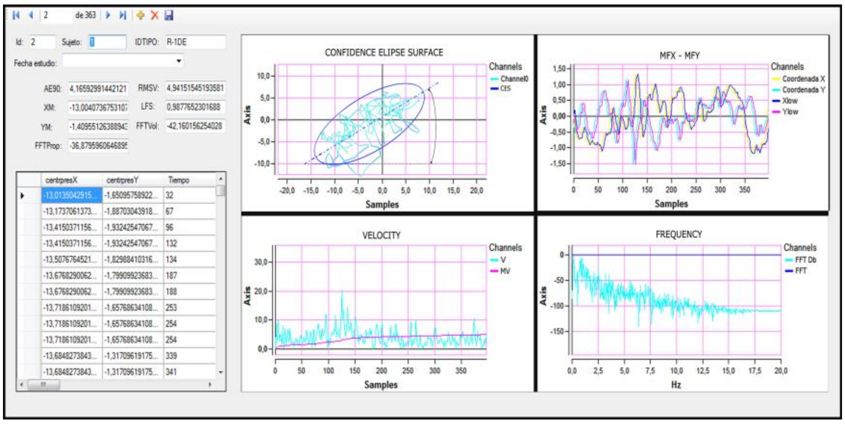

Figure 1. Picture captured from the software used for the analysis of the studied variables.

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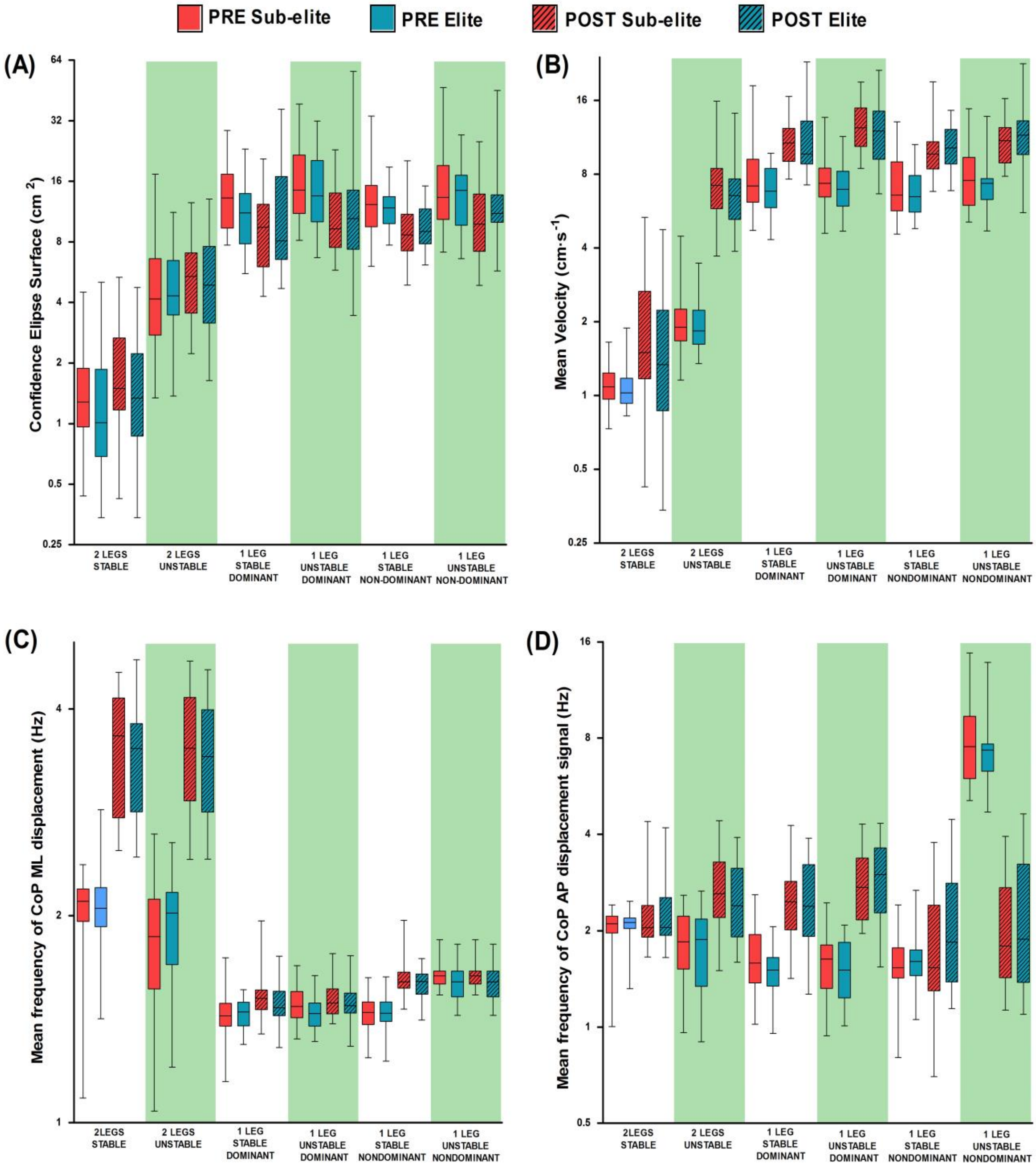

Figure 2. Whisker and box plot showing the data distribution pattern of (A) Confidence ellipse surface containing 90% of the sampled positions of the center of pressure (CES), (B) Mean velocity as average modulus of velocity of the center of pressure (MV), (C) Mean frequency of sway over medial-lateral direction from amplitude spectrum (MFX) and, (D) Mean frequency of sway over anterior-posterior direction from amplitude spectrum (MFY) in each test, according to the competitive level (elite and amateur) and fatigue status (PRE and POST).

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postural performance has been previously examined in middle-aged and older healthy adults (Bizid et al., 2009a; Lin et al., 2009), in patients with several physical disabilities or following important injuries (Wilkins et al., 2004; Ageberg et al., 2004) and in athletes of different team sports (Fox et al., 2008). The majority of these studies have found significant performance declines in all the postural parameters studied (i.e., increase in the velocity and magnitude of displacement of the center of pressure and the center of mass). These findings support the hypothesis that short-term high intensity efforts will produce a decline in the ability to maintain the stance stability, and therefore an increased risk of falls and injuries, or just a drop in athletic performance.

Despite the aforementioned studies (Bizid et al., 2009a; Lin et al., 2009 Wilkins et al., 2004; Ageberg et al., 2004; Fox et al., 2008), to the author´s knowledge, this is the first reported case that simultaneously analyses and compares the stabilometric and the postural balance skills under rest and following strenuous anaerobic exercise similar to those which occur in an official combat match, where the postural stability is essential, like in boxing, judo, taekwondo or wrestling. Our data suggests that the postural stability of wrestlers and their balance performance will decrease significantly as the combat bouts progress. The magnitude and velocity of the performance decline will be particularly important in those wrestlers which have developed a great amount of anaerobic energy expenditure (e.g., when the combat is going disputed and intense). Our data also supports the fact that this balance impairment will be especially decisive if a fighter performs any specific wrestling technique (e.g., fireman’s carry, Olympic lift, duck under and double leg) when the opponent has only one leg support (Table 2).

Contrary to our hypothesis, the result of the present study suggests that once wrestlers reach the national competitive level, their balance performance will not differ from that of their international counterparts, either at rest (i.e., early stages of the combat) or after a strenuous anaerobic effort (i.e., last moments of the bout). These data conclude that, unlike other anthropometric, physiological, neuromuscular and psychological variables studied in our laboratory with part of these subjects (García-Pallarés et al., 2011; Gullón Lopez et al., 2011 RPD; Gullón Lopez et al. 2011 AP) and in other previous studies (Horswill et al., 1989), the postural control skills do not seem to be a key factor in the competitive level of wrestlers. These results are important and unique because, to our knowledge, this is the first study that has been able to compare the balance performance between two competitive levels (i.e., national and international calibers) under fatigue conditions similar to those which occur in a real wrestling combat. Nevertheless, our results are partially in line with those of a recent study undertaken by Paillard et al., (2012) that compared the balance performance between judoists at different competitive levels, but just under rest conditions. These researchers found that the international level judoists were more dependent on visual information to maintain their stance and static posture than national level counterparts, and therefore they concluded that the visual information may be increasingly important in posturokinetic activities as the judo level of competition increases.

Of note, the large standard deviations detected in all the stabilometric parameters studied (see figure 2), at rest or under fatigue conditions, indicated the great individual differences that exist in the magnitude of the balance impairments that occur during short and powerful efforts similar to a wrestling bout. As a practical point of view, the knowledge of the individual balance performance declines that occur throughout a match can help wrestlers and coaches to individualize the technique and tactics required to beat their opponent (Sharratt, M.T., Taylor, A.W., Song, T.M., 1986; Horswill et al., 1992). A wrestler with relatively low balance performance declines may take a defensive stand at the start of the match, tire out his opponent early on, and make his moves to score points later in the match. In contrast, if an athlete knows that he can produce relatively high power output early in a match but may fatigue very quickly due to the great amount of anaerobic energy expenditure generated, he may choose to attack early and win the match in the first periods.

Although no significant differences were found in postural control or balance skills among elite and non-elite wrestlers, a small number of studies have detailed higher postural and balance performance for combat sportsmen compared to other sport participants or sedentary healthy adults (Paillard et al., 2012, Melnikov et al., 2012, Perrin et al., 2002; Rynkiewicz et al., 2010; Leong 2011). In a recent study, Leong et al., (2011) found that amateur taekwondists have better quasi-static and dynamic balance performance compared to healthy un-trained subjects. Perrin et al., (2002) compared the balance control of highly skilled judoists, dancers and controls, and found that only judoists were able to maintain a significant better static and dynamic balance control than non-training ones. Melnikov et al., (2012) compared the stabilometric skills between highly trained Sambo wrestlers and healthy sedentary subjects. These researchers found that wrestlers and non-athletes differ only slightly in their ability to support balance in a basic stance under rest conditions, and a submaximal standardized fatigue protocol leads to a similar decrease in postural stability in both groups. With male and female Sumo wrestlers, Rynkiewicz et al. (2010) found that, under rest and static conditions, males had better results when it comes to the ability to maintain static balance, than females of the same competitive level, probably due to the higher body mass index of males. Also, this research highlights that Sumo sportsmen have higher levels of the ability to maintain static balance than other sportsmen and non-training individuals. All these data support that the body balance of athletes or trained healthy subjects, especially combat sportsmen, is better than the sedentary and untrained people. Nevertheless, when a wrestler reaches the national level, the balance performance cannot be considered as a critical component of success in elite and world-class level of this sport.

CONCLUSIONS

The obtained research results make it possible to draw the following conclusions:

A specific anaerobic exercise protocol produces a rapid and significant balance postural impairment in the static stance of wrestlers, mainly with only one leg support.

National and international level wrestlers do not differ in their postural balance performance, nor at rest nor under strenuous fatigue conditions similar to those which occur during an official match.

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